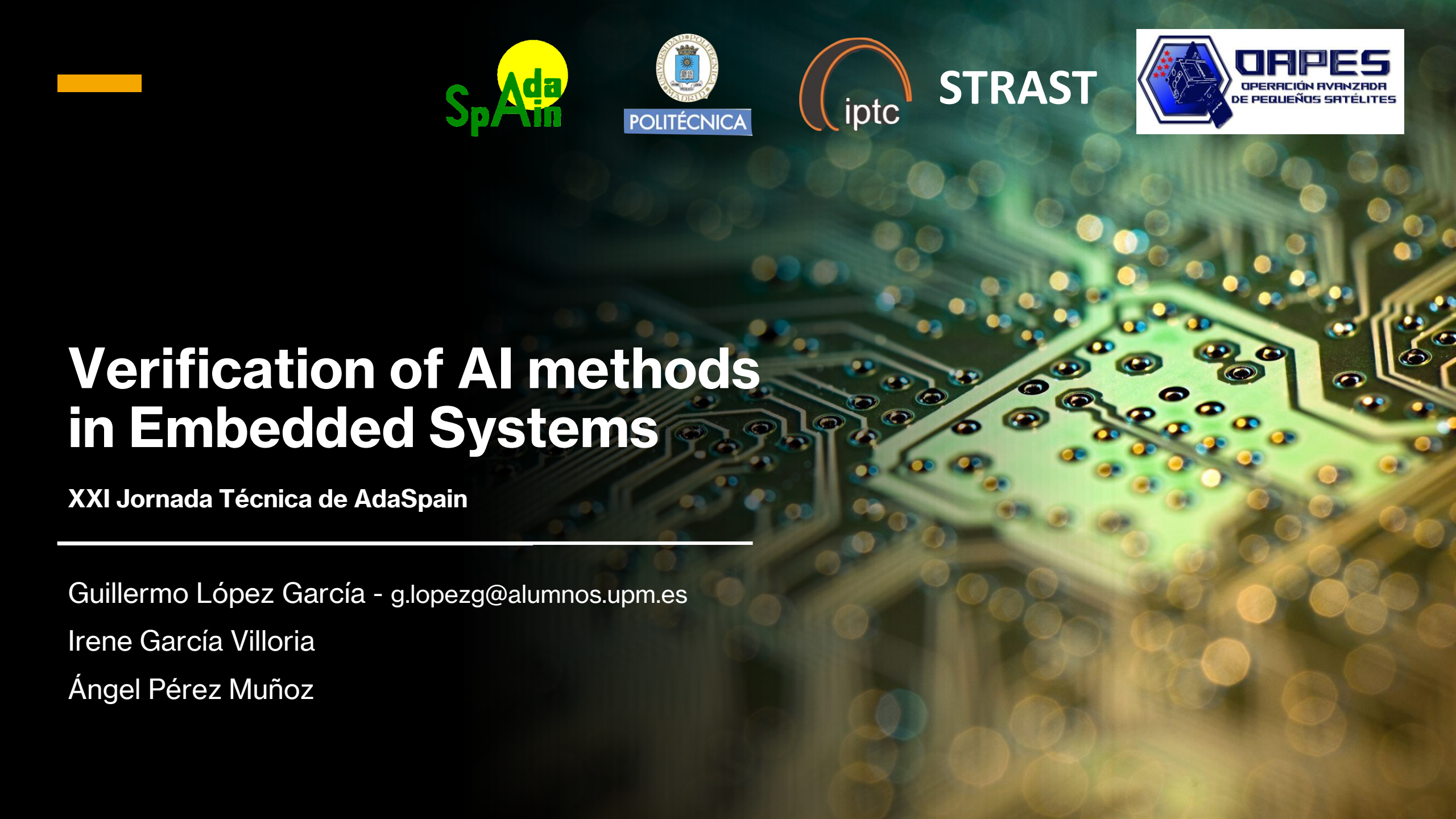

Verification of AI methods in Embedded Systems

XXI Jornada Técnica de AdaSpain

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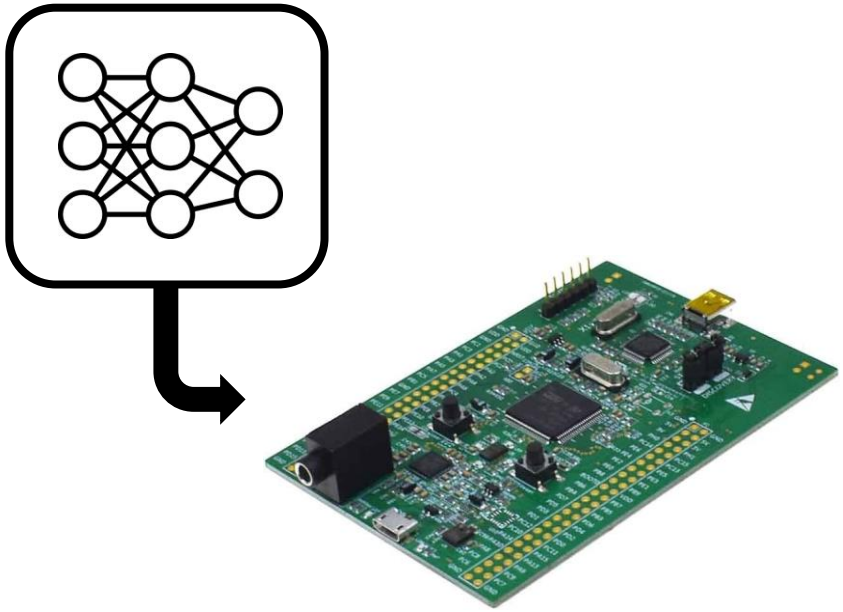
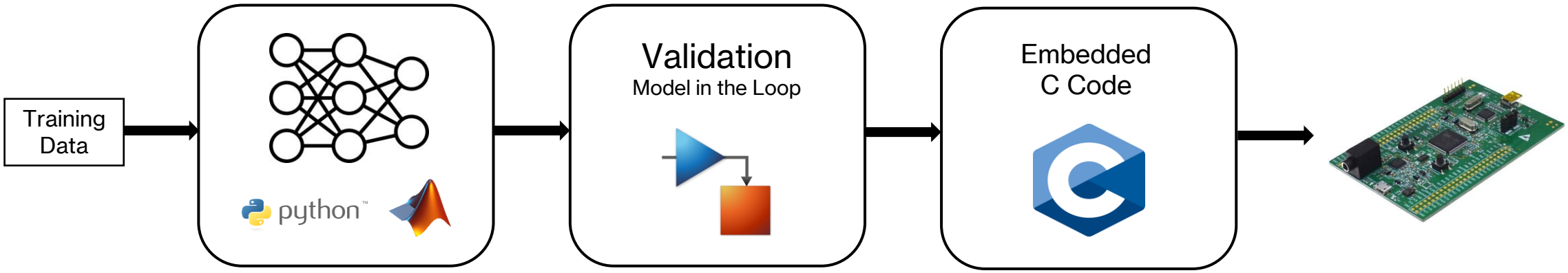
Goals

- Automatic C code generation from Artificial Neural Network (ANN).
- Deployment of the AI model in a system with reduced resources.
- Validation and Verification of the ANN.

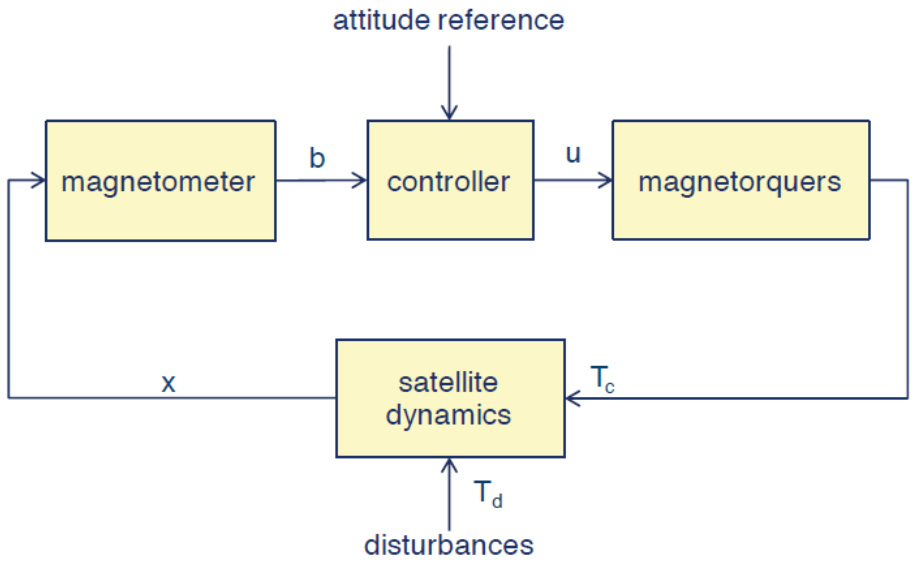


Automatic Code Genartion Workflow

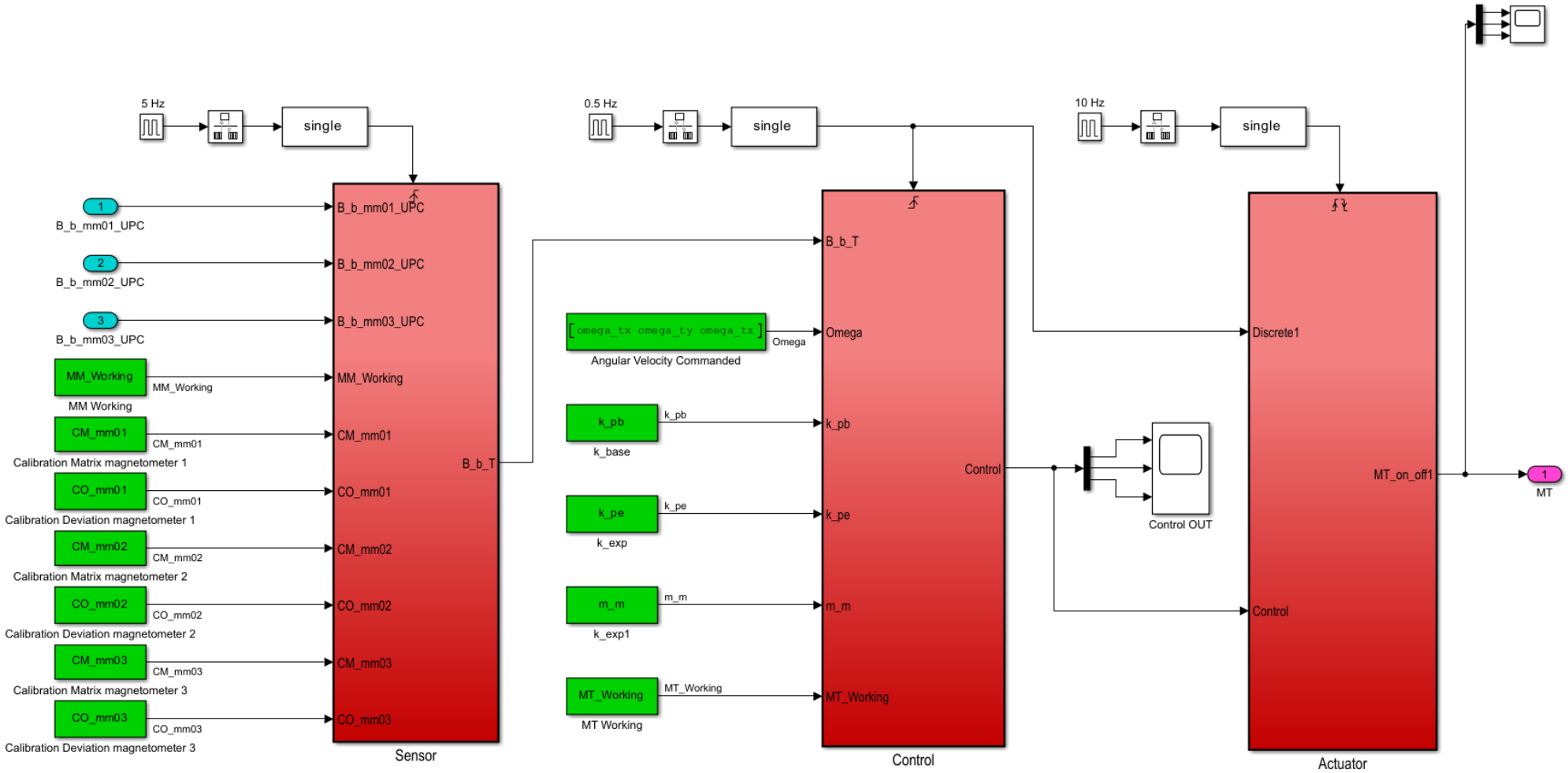


Example: Attitude Control System

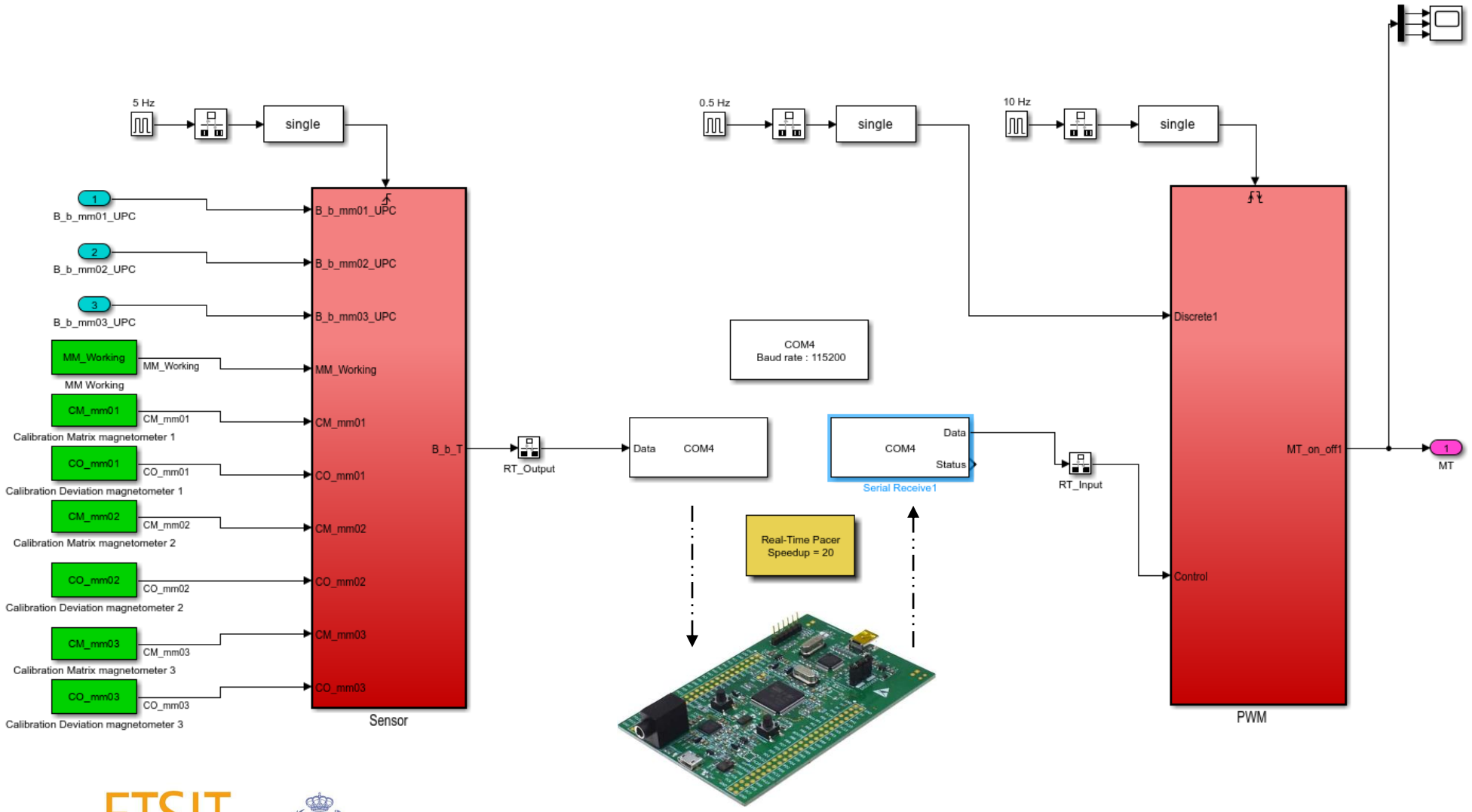
- Attitude Control System (ACS) of UPMSat-2
  - Keep right orientation towards Earth
  - Slight rotation in Z axis
- Sensors → magnetometers
- Actuators → magentotorquers
- Replace controller by an ANN



Example: Attitude Control System



Example: Attitude Control System

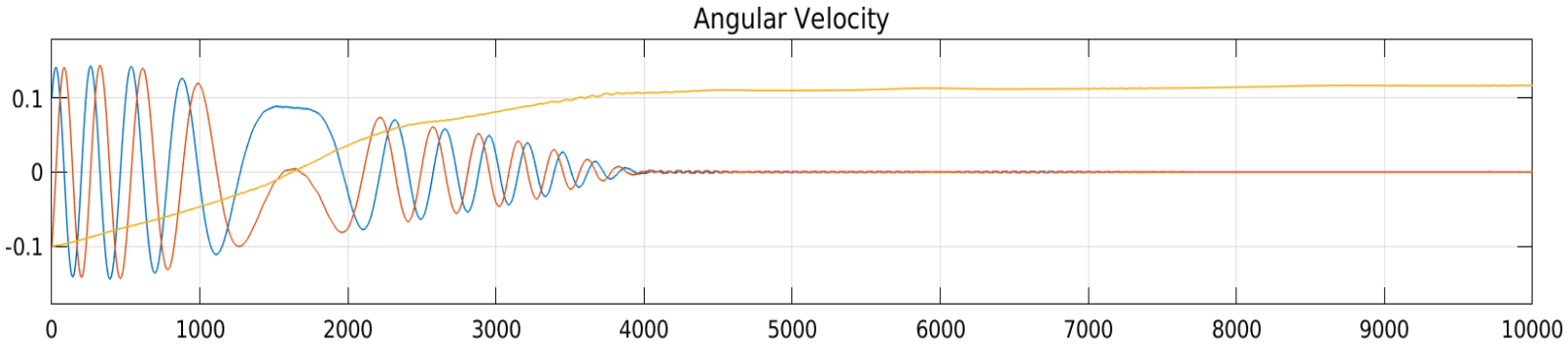


STM32F407

Results

Graph:
Angular velocity evolution of 3 axis (X, Y, Z)

Nominal Control



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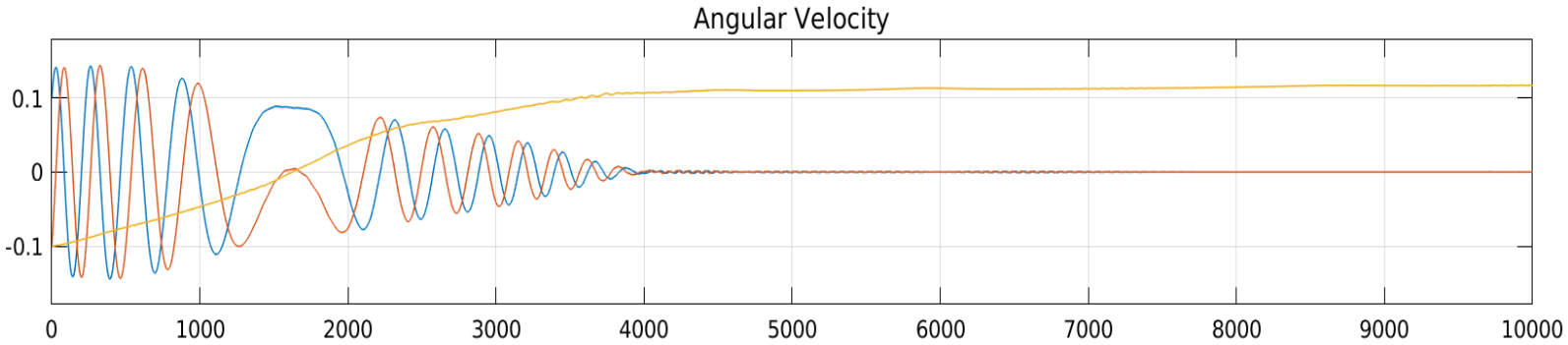
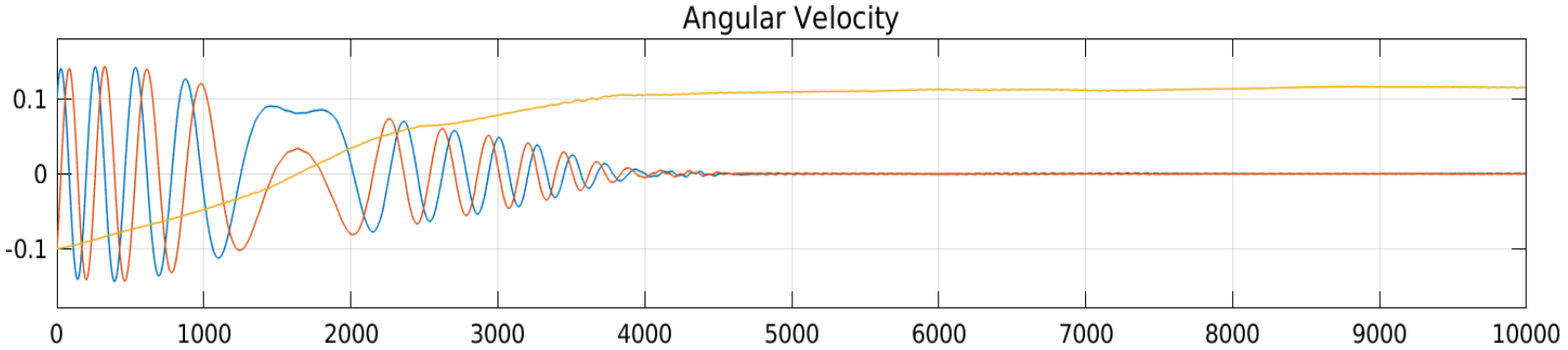
Results

Graph:
Angular velocity evolution of 3 axis (X, Y, Z)

Nominal Control



Artificial Neural Network



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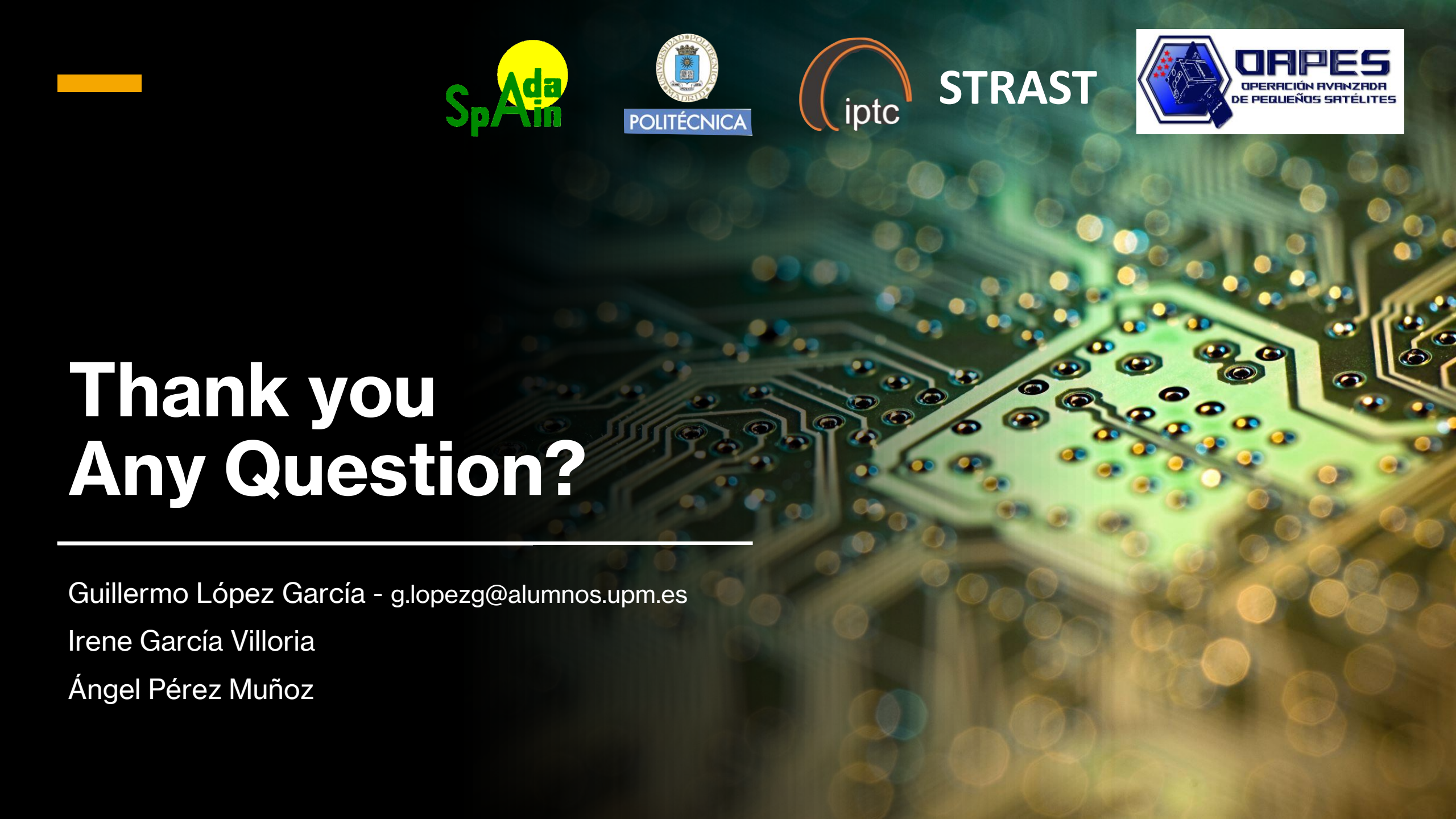
WCET verification

- Real-time requirements → OTAWA
- Computes WCET from executable file
- Needed to specify loop bounds
- OTAWA Results – ARM Cortex M4:
  - `WCET[main] = 1410585 cycles`
  - ~ 8,3 ms
- Ada.Real_Time Results:
  - Average ~ 1,957 ms
  - Min ~ 1,95645 ms
  - Max ~ 1,9573 ms

Conclusions & Future work

- Automatic C code generation from an Artificial Neural Network
- Artificial Inteligence model capable of replacing UPMSat-2 ACS
- Tool for WCET verification → further validation of AI models



Thank you
Any Question?

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